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Back-Up Training Requirements for the Digitized Battlefield: An Overview

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This study report provides an overview of critical training issues facing the Army as the 21st Century Force becomes increasingly digital. The focus of this report is on understanding the significant change brought about by digitization and the ramifications that may result in degraded mode or back-up training requirements. This report is the first of three prepared under the U.S. Army Research Institute's Studies and Analysis effort titled "Back-Up Training Requirements for the Digitized Battlefield." Issues and concerns documented in this report are addressed in two subsequent study reports: "Analysis of Emerging Digital and Back-Up Training Requirements" and "Issues and Recommendations: Training the Digital Force."

The impetus for this effort was provided by the Deputy Chief of Staff for Personnel's Directorate of Personnel Technologies. Of concern was the lack of analysis regarding how the Army should address training and sustaining conventional or back-up skills for operations when digital system capabilities become degraded. This issue will become increasingly important as digitization of the force increases and resources decrease.

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FOREWORD

This study report provides an overview of critical training issues facing the Army as the 21st Century Force becomes increasingly digital. The focus of this report is on understanding the significant change brought about by digitization and the ramifications that may result in degraded mode or back-up training requirements. This report is the first of three prepared under the U.S. Army Research Institute's Studies and Analysis effort titled "Back-Up Training Requirements for the Digitized Battlefield." Issues and concerns documented in this report are addressed in two subsequent study reports: "Analysis of Emerging Digital and Back-Up Training Requirements" and "Issues and Recommendations: Training the Digital Force." These studies are covered by a memorandum for record between U.S. Army Research Institute-Armored Forces Research Unit, U.S. Total Army Personnel Command (PERSCOM), Deputy Chief of Staff for Personnel-MANPRINT, Training and Doctrine Command (TRADOC) Systems Manager Bradley, TRADOC Systems Manager Abrams, subject: Back Up Training Requirements for the Digitized Battlefield dated 29 Apr 96.

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This series of reports will assist senior Army leadership in focusing on degraded mode or back-up training requirements as they affect the areas of Doctrine, Training, Leadership, Organization, Materiel and Soldiers (DTLOMS). The critical issues identified here and subsequent recommendations have been reviewed and discussed in open forum workshops with representatives from the Training and Doctrine Command, Infantry and Armor Schools, Defense Advanced Research Projects Agency, and operational unit personnel.

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BACK-UP TRAINING REQUIREMENTS FOR THE DIGITIZED BATTLEFIELD: AN OVERVIEW

EXECUTIVE SUMMARY

Study Requirement:

Recognizing the Army's need for additional analytic work in the area of digitization training, the U.S. Army Research Institute's Armored Forces Research Unit, supported by the Office of the Deputy Chief of Staff, initiated a studies and analysis effort. The focus of the work was to determine the requirements, potential problems, and proposed solutions for digital degradation and back-up training for the future battlefield. This report, the first in a series of three, provides an overview.

Procedure:

This report documents pertinent findings from literature reviews covering the Army's digitization effort and training lessons learned. Of particular interest were the results of Advanced Warfighting Experiments and simulation-based efforts utilizing prototype digital information technologies.

Findings:

Conclusions of this report highlight the importance of: a) considering the "back-up" training requirements for digital information systems; b) optimizing the use of simulation and distance learning technologies for time and cost savings in training; c) updating and sustaining Programs of Instruction, and Tactics, Techniques and Procedures, and d) developing training strategies that incorporate back-up training.

Utilization of Findings:

This report provides the background for significant follow-on efforts to address the areas of back-up training from the standpoint of the materiel acquisition process, the training development process, and the training management process. A follow-on study has been initiated using the M1A2 tank and M2A3 Bradley vehicles as exemplar systems in analyzing the digitization and back-up training issues and proposing recommended training solutions.

BACK-UP TRAINING REQUIREMENTS FOR THE DIGITIZED BATTLEFIELD: AN OVERVIEW

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Back-Up Training Requirements for the Digitized Battlefield: An Overview

During discussions about the equipment presumed to be routinely available on battlefields of the next century, Robert Heinlein's 1959 foresighted book Starship Troopers is often quoted. Heinlein cautioned advocates of sophisticated technology that a soldier too absorbed in the mechanics of operating his equipment might not notice the advance of an approaching enemy. In sentences less often quoted, the protagonist describes his kinesthetic power suit. "And *that* is the beauty of a powered suit: you don't have to think about it...This leaves you with your whole mind free to handle your weapons and notice what is going on around you" (Heinlein, 1987, pp. 82-83, italics in original). The 21st Century soldier, despite technologies beyond Heinlein's dreams, will nonetheless have to think about what his equipment is doing. Additionally, his qualifications may need to match those of Heinlein's superbly trained soldier -- "a specialist so highly skilled that he would rate 'master' in any other trade" (Heinlein, 1987, p. 27). Unlike the Starship Trooper who faced certain death if his system failed, the soldier on the digitized battlefield must be able to continue the mission in a degraded mode.

In the adventures of the Starship Troopers, Heinlein did not address the possibility of the power suit's failing to respond to its owner's commands. When the suit malfunctioned, the fictional trooper simply could not survive. However, the successful warrior on the 21st Century digitized battlefield cannot afford to become totally dependent on his sophisticated apparatus. He must retain the abilities and competencies necessary to succeed when the equipment is not working. He must continue to do his job without it, or with it functioning only in a degraded mode. Therefore, it is critical that soldiers, crewmen, and commanders possess the "back-up" skills to overcome equipment degradation.

The soldier on the battlefield of the no longer so distant future will have to be a highly competent and flexible specialist. Training will be more important than ever. With the coming changes to traditional methods of fighting, there are lessons learned and lessons to be learned that must be applied before the Army can take full advantage of the potential offered by technology.

DIGITAL BATTLEFIELD

The most significant recent advancements in present day military systems are the combination of improved hardware, software, and supporting equipment collectively known as digitization. According to the U.S. Army Digitization Office (ADO), digitization is "the application of technologies to acquire, exchange, and employ timely digital information throughout the battlespace, tailored to the needs of each decider (commander), shooter, and supporter" (ADO, 1997; Singley, 1995). The ADO mission is to coordinate and integrate battlefield digitization efforts and information technologies as a part of the Force XXI campaign plan. The ADO is responsible for assessing and applying these technologies across the operational army to increase the lethality, survivability, and tempo of operations.

Digitization integrates digital information technologies across the battlefield among combat, combat support, and combat service support systems and units. Its essence is communication; its goal is total situational awareness. Situational awareness is defined as the "ability to have accurate and real-time information of friendly, enemy, neutral and non-combatant locations; a common, relevant picture of the battlefield scaled to specific level of interest and special needs" (U.S. Army Training and Doctrine Command (TRADOC), 1994, p. G-7 and ADO, 1996). The 21st Century combatant will operate in an environment in which friendly forces share a common picture of the battlefield while accomplishing their move, shoot, and communicate tasks. Currently, the Army's suite of evolving digital technologies includes an uneven mix of vehicle-integrated, vehicle-applied, and non-vehicle based digital information systems. As these systems become progressively integrated and available, however, the impact of digitization will be felt in changes to the way battles are fought, and in leader planning, preparation and execution of assigned missions.

Digitization will permit soldiers at every echelon to operate in concert, sharing critical data across echelons (ADO, 1995). Digitization will permit near real time information exchange, enabling a commander to visualize and impact on a large area of the battlefield. Enhanced awareness of friendly and enemy forces should enhance synchronization and reduce fratricide.

General William Hartzog discussed the challenge of embracing digitization. It must be a "path of exploration that will allow soldiers to be enhanced rather than encumbered by these emerging technologies" (Hartzog & Canedy, 1996, p. 19). He continued: "Training will remain a top priority...If anything, the amount of

information available will magnify the importance of soldiers in the loop and their judgment" (Ibid. p. 22). Digital equipment can revolutionize the amount and quality of information available and how it is used. Simulations, simulators, live training and distance learning (for individuals, units, and self-development) will be affected. Logistics will be anticipatory rather than reactive; en route mission rehearsal will be possible. Real time situational awareness may link all echelons with joint forces worldwide.

Digitization will allow commanders and staffs to see the battlefield while communicating with each other, and effectively target the enemy. Technology-enhanced communications will provide new capabilities for creation and dissemination of overlays and graphics, and will permit soldiers to update reports on an almost continuous basis. Enhanced situational awareness will bring improved performance and synchronization through a mutual understanding of the dynamics of current and likely future battlefield situations. (An extensive discussion of human factors and situational awareness is found in a 1997 National Research Council publication, *Tactical Display for Soldiers*.)

Battlefield digitization will lead to automation of certain tasks, and a concomitant reduction in the requirement to perform other tasks. Also there may be new tasks and/or modifications to existing tasks. There will be changes to the overall number of tasks, and in the manner of performance to accommodate new requirements imposed by that same digitization.

The bottom line, however, is that soldiers must maintain proficiency with older systems while gaining proficiency with the new. In the case of digitized systems - susceptible to failure, enemy countermeasures and environmental factors - there will be skills and task training requirements for effective back-up operations when systems are degraded, disrupted or otherwise compromised. The differences in expertise needed may have implications for personnel skill requirements and for training.

OVERVIEW OF MAJOR DIGITIZATION ISSUES

The following sections will address issues related to this new equipment and how it will be fielded. Of concern also is the impact of this equipment on soldiers - their capabilities, skills, and training requirements. Digitization brings new ways of looking at old things. Then Colonel, now Brigadier General J. M. Dubik, a commander during the Dismounted Battlespace Battle Lab's 1995 Warrior Focus Advanced Warfighting Experiment (AWE), addressed the impact of technology on the battlefield. He stressed the need for balance between technology, doctrine, soldiers, leadership and training. He was quick to note that no

matter how sophisticated the equipment, the "fog of war" will remain, although "commanders will benefit from a quantum improvement in what they know about their enemy and their own unit, and in their ability to decide and act faster than their enemy"(Dubik, 1996b, p. 3). The digitized soldier will be required to discriminate between multiple bits of information. Management of this information will be critical. Dubik spoke with urgency: "We can't wait until the technology is developed fully to begin training leaders to make computer-assisted decisions or to lead under conditions completely different from those with which they are now familiar. That will be too late. Technology is changing at a rate faster than our leader training...Leader preparation should begin now... " (Dubik, 1996b, p.16).

Technology and Equipment

There are numerous sources available to describe the digitized equipment designed to enhance survivability and lethality and tempo. Although some items will be highlighted for illustrative purposes, the entire listing, together with capabilities, need not be provided here. Descriptions and rationales are available in, for example, FMC Corp. (1988), United Defense Limited Partnership (1996); Glasgow, Cardine and Latson (1996); and Elliott, Sanders and Quinkert (1996). Additionally, the annual Army Green Book provides up-to-date information on technology's advanced equipment (see Association of the United States Army (AUSA), 1996b).

The capabilities provided by advanced equipment will be many. For example, the Global Positioning System (GPS) with digital compass improves navigation. Command, control and navigation software (POSNAV) provides status reports and locations which through the commander's and driver's integrated displays (CID and DID) give vehicle position and headings. Technological improvements provide an enhanced position location reporting system (EPLRS). A commander's independent thermal viewer (CITV) with 360-degree surveillance provides day and night hunter-killer capabilities. The Improved Bradley Acquisition System (IBAS) is an integrated day/night second-generation thermal sight.

Enhanced lethality comes from improved target acquisition, full solution ballistic fire control systems, automatic boresighting, and hunter-killer capability (the commander searches while the gunner services a target). Bradley Fighting Vehicle (BFV) squad leaders will have a forward-looking infrared radar (FLIR) monitor/display in the troop compartments of their vehicles. Further equipment summaries are available in, for example, Fedak (1996); Hasenauer (1995); Willis (1996); McHugh

(1996) and Motorola Corp. (1995). The Force XXI Land Warrior for dismounted soldiers will have a thermal weapon sight, digital compass, helmet-mounted display and laptop computer. Commentary on digitization of the individual soldier is available in the U.S. Army Infantry School Warrior Focus report (1997).

Although digitization is discussed as a foregone conclusion in the popular press, fielding is a slow process. By 2015 only 1079 of the Army's 7000 tanks are expected to be digitally integrated. Fielding or the M2A3 Bradley Fighting Vehicle begins in the year 2000. In the post-Operation Desert Storm focus on reduction of friendly fire casualties, there has been increasing interest in enhanced situational awareness for the heavy force (Steele, 1996a). In 1996 the 4th Infantry Division's brigade-sized experimental force (EXFOR) at Fort Hood, TX (and at Fort Lewis, WA) took possession of digitized equipment on a test basis in preparation for the March 1997 Task Force XXI AWE at the National Training Center (NTC). The AWE was designed to assess effects of equipment and organizational changes on warfighting capabilities across all the Battlefield Operating Systems (BOS).

The EXFOR explored the capabilities of digitized equipment to provide enhanced command, control, communications and intelligence (C3I) and contribute situational awareness to echelons that previously have had little or none. Future Battle Command Brigade and Below (FBCB2) equipment (early versions known as Appliqué) will provide this capability to platforms that do not have internal digital capabilities. Appliqué consists of a GPS, a Single Channel Ground and Airborne Radio System (SINCGARS) and/or EPLRS radio and a laptop computer (commercial, ruggedized or militarized) with appropriate software. More information on the EXFOR is found in Patterson (1997), Naylor (1996c, 1997a and 1997b) and AUSA (1996a). Hartzog and Canedy (1997) provided an overview, Rosenberger (1996) described "a year in the EXFOR," and Steele (1996 a, b) interviewed the EXFOR commander. Other summaries have been provided in, for example, materials from the 1997 Infantry Conference (Hartzog, 1997).

Computers for the Battlefield

Computerized systems for the battlefield environment present special human factors and engineering issues beyond the implicit needs for ruggedization, weatherproofing, and portability. In military usage, high-resolution display panels or screens that can support multiple color graphics, using reliable and quiet power sources will be important (National Research Council, 1997). Digital displays must be easily read, from many aspects, to accommodate viewing from many angles or positions within, for example, the confines of a turret.

Maintenance issues expand on the digital battlefield. These are questions about repairs to sophisticated equipment, and understanding system connectivity. Network issues abound. Local and wide area networks require commonality. Given the military mission, both print capabilities and system redundancy are needed to ensure continuity. Only half in jest the question is asked: in the case of a software glitch and loss of functionality, will the tank crash like a laptop? If so, who can fix it? And how will they fight while the system is down?

Provision must be made to ensure common databases, across all systems. The overall database must address the fact that different missions, to include stability and security operations, will need different kinds of information. Light and heavy forces do not operate on the same sized battlespaces. The greater speed and ground covered by a mechanized unit requires a larger terrain database. Weather information will have different impacts on different kinds of units. There may also be differences in the data required for active and reserve components, depending on equipment. The slice elements, traditionally in battle with but not as an organic part of maneuver units, have digitization needs of their own, complementary to those of the combat arms.

Long distance widespread interconnectivity is needed on the battlefield between units who cannot see each other, and in many cases do not know each other. Combined arms communication links must be integrated. There must be common equipment across systems with compatible, integrated and user friendly software. The tank's battlefield combat identification system (BCIS) provides combat vehicle identification with automatic authentication through the laser range finder -- but only if both systems share the technology (Gourley, 1997).

Security

Technology requires other new ways of thinking. To ensure operational security, new disciplines and countermeasures must be planned to reduce the possibility of compromise and protect sensitive information. Many authors have shared this concern (Cooper, 1996; Thomas, 1996-1997; Hudson, 1996; Grange & Kelley, 1997; Anthony, 1997; Merkle, 1997). Cyberspace users may "betray their own position in space and time" (Bunker, 1996, p. 115). This "window of vulnerability" makes it imperative that forces protect and use their information wisely. Glashow (1996) stressed the need to identify other vulnerabilities. The wrong command can erase files or shut down communication. Passwords must be protected. Information that cannot be trusted will be ignored. Commenting on security of digital communications, Naylor (1996b) suggested that the credibility of an icon on a

may not have the same credibility as the commander's voice. (See also Dubik, 1996a.)

Computers are susceptible to attack, by direct and indirect means, and through unauthorized gain or access (Jacobson, 1995). Software can be altered, damaged, destroyed. By compromising, manipulating or corrupting data, operations may be disrupted and equipment no longer function as designed. Information may not reach the intended recipient for any number of reasons. As an example, GPS is susceptible to jamming (a barrage of electronic noise) or spoofing (incorrect locations). Jacobson provided a strong warning that digitization is not a panacea:

> Soldiers and leaders must maintain their soldier skills and must be vigilant of the digitized information they receive. Land navigation must be practiced for when the GPS stops working, and all information must be critically reviewed for accuracy and relevancy to the current operations; do not assume that the information you get, even that coming over encrypted systems, is complete or entirely accurate. Backup files and hard copies of graphics, plans, documents, and databases must be maintained in case the computer hardware or software is destroyed or damaged. Additionally, methods must be developed and practiced that verify the received digitized data as correct, complete, and has not been corrupted. (Jacobson, 1995, p. 3.)

Enemy capture and utilization of digitized information is a real possibility. Furthermore, the methods for digital authentication differ tremendously from conventional systems. Units must develop standing operating procedures (SOPs) for protecting hardware from capture or at a minimum, deleting information. Merkle commented on potential electromagnetic threats to digitization. He cautioned that it is important to develop countermeasure strategies and technologies, to include basic skills that must be retained since if there is attack, technology will be unavailable. He provided a reminder: "Gadgets and gizmos do not take and hold terrain, nor do they fight and win on the battlefield - well trained soldiers do!" (Merkle, 1997, p. 39).

Doctrine

Technology's impact will be felt in doctrine, well beyond the scope of increased situational awareness. Meadows (1996) and Holzer (1996) report on Joint Vision 2010, describing future multi-service warfighting concepts of dominant maneuver, precision engagement, full protection, and focused logistics.

Digitization of the battlefield will provide empowerment at these new levels. Theoretically, every soldier could ask for and receive whatever information is needed in order to follow the commander's intent. Digitization will enhance, change, and add to doctrine -- but does not yet replace current concepts of employment. Soldier roles must not be defined by the need to operate digital equipment but, rather, by requirements to perform mission essential individual, crew and collective tasks (Graham, 1995).

However, as skills and confidence build in the digital force, doctrine will evolve to advantage more and more of the flexibility afforded by detailed, early, and accurate battlefield information. Changes to doctrine must consider the requirement to execute operations in the "back-up" mode should that become necessary. This could require not only knowing how to perform back-up tasks, but the back-up doctrine that goes with those tasks as well.

Special Text 7-20-3, the Digitized Infantry Battalion (Department of the Army, 1996), suggests caution using new digitized equipment, particularly when fielding is incomplete. A mixed force with some elements digitized and some not digitized will cause complications. There are few real plans for training for or accommodating a mix of digitized and non-digitized vehicles on the battlefield (Heun, 1996). More than just vertical, digitization will be horizontal, including combat support and combat service support elements as well as maneuver and fire support elements. Ground forces will receive information from aircraft, satellites and allied nations. There is great potential for a mixed force where some but not all have digital capabilities and therefore cannot share all of the same information (Howard, 1996). All the sophisticated equipment and the information it provides may bring the "new fog of war" – one caused by an overwhelming (or inequitable) amount of intelligence and communications data (Graham, 1995, p. 3).

Cognitive and Other Soldier Skill Attributes

Discussion of technology's impacts on the soldier is widespread. The challenge is to integrate technologies to automate warfighting functions in such a way as to assist, not hinder the soldier. Echoing Hartzog, Longhouser cautioned, "We cannot transform our crews into computer operators. We must be able to take the outside world of interconnectivity and information, bring it into our systems and automate it so that it increases warfighting capability without additional burden on the soldier" (Longhouser, 1996, p. 5). Need must drive technology, not vice versa, and "digitization should be more than "appliqué of new technology on old processes and hardware" (Casper, Halter,

Powers, Selva, Steffens, & Willis, 1996, p. 84). This message was echoed in interviews with Infantry leaders (Graham, Valentine, and Washington, 1997).

Several authors have tried to describe the cognitive skills and performance capabilities required by a Force XXI soldier and the qualities needed to deal effectively with the rapid flow of information in a high stress environment (Naylor, 1996a; Tice, 1995a and 1995b; Halpin, 1995). The soldier must have the "ability to quickly determine the relevance of the information received and to use effective judgment [to] respond effectively to the situation rather than being overwhelmed by information overload" (Rumsey, 1995, p. 6).

Harig (1996) discussed the long-term impact of technology on the military, speculating that future leaders will begin to think differently as a function of their technological capabilities. He also warned of a danger in the blurring of reality and virtual reality, when the computer screen's icons may become a substitute for real people. Will war, as played out on a digital screen, become just another video game? Similarly, Grimes (1997, p. 14) interviewed and quoted Bramlett: "It is easy to become mesmerized by moving forces in a computer. They are put into position and then the battle happens on the screen...Tanks do not move like icons." Soldiers must retain and exercise the capability for critical thinking.

Similarly, reporting on the AWE Warrior Focus at the 1996 Infantry Conference, Dubik (1996a) posed questions about confidence and cohesion. Can you trust a buddy who is only a blip on the screen the same way you learn to trust a voice? How do you build cohesion in the increased dispersion of a digitized battlefield? Dubik noted that although some things benefit from digitization (databases, planning, orders), others (staffs working to develop a course of action) may not.

Technical and conceptual skills develop differently. Current thinking is that commanders need face to face leadership communication skills, whereas advancement of their skills as computer operators may be less critical. However, operators of computers must be more than clerks; they must be integrators and managers of information, and decision-makers. The person at the computer screen may be the one who commits the force. Is that individual an officer or a sergeant? New soldier, leader, and unit relationships will develop. At a minimum, personal information systems and loosely organized information networks and enlarged battlespace represent a conceptual shift for commanders and staffs.

However, for the generation that has grown up with computer games and video arcades, capabilities offered by a digitally enhanced battlefield are almost expected, and their absence might be more notable than their presence. Familiarity with the Internet or E-mail means that soldiers already know that information and misinformation can easily be transferred from one site to multiple others. What they may be less familiar with is inability to communicate due to such factors as opposing forces, weather, and terrain.

There may be undesireable possible impacts from the information barrage that comes with digital communication systems. "Turning knowledge into action will be, in the information intensive environment of a digitized battlefield, a stressful task that could exceed the cognitive and sensory limits of the soldier" (Davison and Taulbee, 1995, p. 5; Naylor, 1996a). Commanders and soldiers must make tactical decisions readily, not hastily; they must take time to assimilate and evaluate information.

Although digitization speeds up the acquisition of the information on which a commander must make up his mind, it "does not, however, speed up the rate at which he can think" (Keegan, 1996, p.37). Rose discussed potential pitfalls of the near real time dissemination of information, down to the lowest levels. He cautioned that information management will require both training and practice, with rehearsals to avoid "plugging the pipes" and ensure only critical information is transmitted. Sharing a concern expressed by many, Rose stated that personnel "need to keep the commander's intervehicular information system (IVIS) screen updated with what he needs...not cluttered with nice to know information" (Rose 1996, p. 5). Removing or eliminating the irrelevant will be particularly important. The commander must delegate to subordinates. The challenge will be to design a useful and useable system that a military commander can control, not one that controls him (Keegan, 1996).

A key aspect in the design of new digital command and control systems may be the ease of transitioning between degraded and nondegraded modes of operation. It is important to promote positive training transfer from manual to digital systems as well as from digital to manual. Train-down requirements include unexpected equipment failure and degradation, and the more predictable but inevitable transition to conventional equipment. An analogy can be found in MicroSoft's use of the desktop as a metaphor for how their office application software is presented to the user. This facilitates transition between conventional and digital execution of tasks. Can a similar metaphor be incorporated into emerging digital command and control systems in the Army that would minimize the cognitive workload?

Information Management

Digitization, well implemented, should provide current and accurate information on enemy and friendly forces and improve situational awareness. It will send reports, messages, graphics, and orders, and link sensor systems that locate targets with shooter systems that kill them. Better informed commanders will be able to make and execute tactical decisions faster than his adversaries, to get inside the enemy's decision cycle. Implementation, however, must include strategies for information management, with special emphasis on handling the increased workload and message traffic over the 24-hour digital day. Although there are limits to the amount of information that can be passed over wireless networks (Naylor, 1996c), there will still be considerably more information than present day commanders and staffs are used to.

Differences between routine and critical information such as the commander's critical information requirements (CCIR) must be addressed. Dubik admitted that during Warrior Focus they "didn't know" what they didn't know. The challenge is to provide the correct amount of information when and where the commander needs or wants it, and in the correct amount of detail. As both officers and Non Commissioned Officers (NCOs) make new kinds of judgments they must gain experience in deciding what data are important. Prioritization of messages containing audio/visual warnings will be critical. Formats must efficiently accommodate message receipt. To receive and then review messages takes time. Duplicate messages may waste time, but redundant messages to the commander and executive officer (XO) may avoid some costs if one is attrited.

Digitization will enable a whole new way of thinking. Obvious factors will be the increased precision, speed, volume, and sharing of information. It may reduce the planning cycle by eliminating time consuming staff processes and the time required for orders to be created and published. Graphics copied on acetate (with varying degrees of accuracy and legibility) may disappear, but the requirement for face to face briefbacks will not. New SOPs must be developed for message dissemination, filters and priorities. Without SOPs, important information will be repeated needlessly; or intelligence will be lost because messages were not tracked correctly or commanders were overwhelmed.

The way the information is configured is important. It must be in a useful format, comprehensible at a glance, so operations will be simplified, and the number of soldiers in the tactical operations center (TOC) reduced (Rosenberger, 1996). Software

must be user friendly with easily read screens and icons that permit the commander and staff to get information they need without removing their eyes from the battlefield for very long. Shared directories and files and standard information processing addresses must be rolled into SOPs. Information management will be key. Besides decisions on who gets which messages in which order, questions arise on who decides what to keep, what to throw away, what to save to disc as back up, and what to print in hard copy. Finally, but perhaps most critical to the success of digitization, the system must be reliable.

Systems that have high reliability still break. Opposing forces, weather, and terrain features will still be able to degrade electronic capabilities. To deal with this, redundancy has become the byword of the industrial age. However, until self-healing software systems are common place, "graceful degradation" must be the byword for the information age. This means having back-up systems in place that smoothly transition not only the weapon system capability, but also the operator's performance requirements with respect to information management.

The soldier of the future, frequently college educated, and a high school graduate at least, may have acquired entry-level computer skills long before entry-level soldier training. Keyboard and icon familiarity may not readily translate to the screens and devices within a turret. Computer training, although widespread for the future generation of soldiers, will still respond to the garbage in/garbage out (GIGO) model. SOPs are needed to "update" and "save" as well as to preclude or minimize operator errors (inadvertent deletions or incorrect data entry). Decision making and information management in the fast-paced stressful military environment requires far greater skills than simple icon manipulation. While basic computer skills will be necessary, they will not be sufficient. Decisions must be made about the type, location, sequence and rate of computer training, and about the mix between computer skills and soldier skills. Rehearsal time, already scarce, may become even more critical, as the balance between computer skills and leadership skills comes into consideration. Achievement of leader proficiency in computer based tasks may become a major time drain.

Training

For position/location indicators and multi-access communication systems to be effective, there will also be a need for well-trained soldiers. Digitally updated training devices, whether for command and control, gunnery or maintenance, must also be planned for and funded to accommodate the demands of the digitized environment (O'Dell, 1995). Resource availability, dollars as well as equipment, will be more critical than ever.

An overview of the Force XXI Training Program contains the warning that "the one area that presents perhaps the greatest challenge is that of training the force" (Martin, 1995, p. 40). Hiller, Wallace, Marcy, and Akam (1995) articulated part of the problem: "In the past, an already complicated unit training program was always stressed by the fielding of new equipment, changes in tactical doctrine, and typically late arrival of individual training, maintenance, and collective training programs" (p. 12). For Force XXI, as for any other situation where new materiel systems are introduced, training should be developed in parallel with equipment and doctrine. It is planned that digital skills will be acquired, perfected and maintained in institutional and unit training, and through self-development. Training will be an on-going and continuous process, from initial entry training through the noncommissioned basic and advance courses, and through officer functional area training. Digital skills will also be accrued through just-in-time training, or embedded training on actual equipment. Units will provide resources as required in support of the operational mission. This plan is a long-range goal. It will take some time to begin achieving it.

Training becomes a greater challenge when both old and new skills must be trained and retained. Basic fighting skills (also called fundamental combat skills) must still be trained along with individual computer familiarization skills. These computer familiarization skills should include as a minimum, for example, nomenclature, knowledge of components, and operating a Windows-based system (Merkle, 1997; Poling, 1996; Graham, Valentine & Washington, 1997). However, training for digitization and the tactical use thereof is more complex than just switchology or learning how to operate new equipment. The location and sequencing of this training must be determined by duty position and echelon. How to accomplish the training remains in question. The Focused Dispatch lessons learned advised that "immersion in a stressful digital message environment was the key to learning to handle and filter battlefield information" (Elliott, Sanders & Quinkert, 1996, p. 79). Training issues include the often overlooked distinction between preliminary, introductory training (learning) and sustainment training (practice), or between training (generalized practice) and mission rehearsal (specific combinations of tasks) (Dewey & Thompson, 1987).

Research will likely be needed to determine the optimal learning strategy by functional requirement. For example, for navigation tasks it may be optimal to learn the manual methods for reading a map (e.g., learning resection/intersection) first, and then learning how to use a hand held GPS or the driver's steer-to-indicator in a tank. However, it may be easier to learn

battlefield report requirements by over-practicing the entry of battlefield information into pre-formatted message displays of IVIS or FBCB2 than to memorize the elements of the nuclear, biological, chemical (NBC) report.

Brown cautioned that "until computer application proficiency ... joins physical fitness and weapons qualification as part of non-negotiable leader proficiency ... practical assimilation of the 'digital' future appears questionable" (1995, p. I-8). Although the caution may be overstated, it is true that if a digital system is in use, everyone must understand its capabilities and limitations. Until all are trained for digital operations, the "old" way (voice radios and hand written notes) should be put aside until and unless needed for "back-up" when the new system is inoperable. The only way to use and share digital information is for everyone to speak the same digital language (O'Dell, 1995; Dubik, 1996a).

Questions arise about skill retention. Complicated equipment, often difficult to learn to operate in the first place, is frequently unforgiving of errors. Intricate procedures and complex skills are forgotten with disuse. As observed by Elliott, Sanders and Quinkert (1996) after Focused Dispatch, many digitized skills are very perishable. Besides allocations of time and place to train new tasks, there must be acknowledgment and agreement on the need for the practice of those tasks. Additionally, for the digitized force there will be a combination of new tasks, modified old tasks, and unmodified old tasks. Time must be made available to accommodate all three.

Technology is advancing so rapidly that fielded equipment may become obsolete quickly; compared to what is available elsewhere, the military's digital capability may be lagging. Multiple versions of software packages are problematic. This coupled with, for example, several different fielded variants of specific vehicles, complicates training. Communication between digitized and non-digitized forces will require considerable planning. Additionally, how will a soldier trained and certified as, for example, an M1A1 master gunner be trained on the updated M1A2 system, and who will keep track of (or know to request) this training? Where will this training occur? Conversely, how will the soldier, trained from his first days on a digital system such as the M2A3 vehicle, gain the ability to deal with the less sophisticated M2A1 when he changes units? Will he be able to estimate range accurately without his laser range finder? Will the commander who has learned to depend on the built-in GPS be able to navigate without it when the GPS capability is degraded or lost?

Questions arise on who needs to be trained, and at what level. Echoing Heinlein, is there a danger that the leader, engrossed in his technology, will be too busy to lead? Which subordinate leaders will be making decisions? Aviators learn that in a two-person cockpit, one must look outside while the other watches screens and dials inside; neither environment can safely be ignored. Similarly, the vehicle crewmembers must be constantly aware of what is inside and what is outside their immediate space. Situational awareness, always critical, and increasingly complex, becomes more important when the system in question can move very quickly and shoot at long ranges. Knowing when to stay focused on the icons on the flat panel display screen or when to pop the hatch and look outside for a full unobstructed 360 degree view becomes a training issue that must be addressed.

Soldier quality may affect the need for and frequency of sustainment training. There will be individual differences in interpretation of information and how to remember what went on before, more important than before because of dispersed units and fewer control measures. Cooper discussed the computer reliant Army, Air Force and Navy of the 21st Century where troops will have "the equipment necessary to transform them into supersoldiers as deadly as tanks and as reliable as surveillance satellites" (1996, p. 30). Despite Cooper's suggestion that the soldier will become a platform as powerful as a tank or helicopter, and should thereby be able to lift or ameliorate the "fog of war," people do not respond in the same way to different technologies. Some will not take full advantage of the new information technology. Shift changes may lead to different interpretations of digital information, and a commander might not get the same intelligence from two different reconnaissance teams. Similarly, leaders do not all perceive information in the same way and all have different frames of reference, experience and intuition. The ability to collaborate or synchronize becomes a greater necessity (Rosenberger, 1996). Planning will encompass new ways of thinking, as commanders learn to rely on visual computerized information rather than on the traditional auditory feedback. There will be differences in reactions to what is seen vs. what is heard, for battle tracking, drills and rapid movement. When a system malfunctions, how will the commander know if one of his subordinates is "off line," and what he can do about it?

Battlefield management will be different. Commanders will learn new ways of thinking about the battlespace and must master a more complicated, and possibly higher, art of battle command. Technology should mass combat power, increase success, reduce fratricide and control the operational tempo of battle. Digitization can help a commander "see" the enemy and assess

capabilities and intent. Commanders will act as information filters, requesting and receiving CCIR. Instead of the traditional sequential planning with information passed down from higher headquarters, planning may become simultaneous, skipping echelons. Where there is visible contact on the battlefield - i.e., more information, more of which is real-time - some leaders may appear to micromanage as higher echelons will be able to directly monitor and control subordinate units. Dispersion, increasingly possible on the digitized battlefield, requires that leaders have more confidence in subordinate leaders. Commanders closest to the fight will be called upon to make more decisions. This may bring changes in leadership styles. Decisions must be made about detailed control (specific instructions with little flexibility) vs. directive management. A leader who has received only directive management may, when he is ready to lead, be unable to do so if he has had no practice (Brown, 1996).

Another question arises for stability and security operations -- will allied nation personnel be trained on digital equipment? For mechanized infantry units, when the vehicle commander (platoon leader, for example) dismounts, who still on board the vehicle will be aware of what has transpired?

Crew stability and cross level training may gain in importance with a requirement to minimize the impact of turbulence and turnover in the unit, especially in the TOC. Decisions must be made about training soldiers new to a unit. When a new soldier enters a unit or a subordinate team within the unit, both individual and small team or collective task proficiency must be revalidated. This requirement will not diminish with digitization. Units do not have the capability, knowledge or time to train new people without improved training resources. Training support packages will be needed. Digital equipment may require considerable individual time to gain and retain proficiency.

LESSONS LEARNED

In keeping with an overall caveat to learn from experience, some preliminary information from the digitized battlefield is included next. This information is based on the actual experiences of those involved in the recent AWEs that address digitization issues. This review summarizes some of the AWE lessons learned but not yet applied.

Operation Desert Hammer VI

While much of the emphasis on digitization of the battlefield has concentrated on hardware and software, this review concentrates on training issues. The April 1994 NTC

Rotation 94-07, AWE Operation Desert Hammer VI, demonstrated the potential of information available through digitization. The AWE's purpose was to develop insights for Force XXI by having a full battalion task force complete a rotation with new equipment. In Desert Hammer and other AWEs, certain recurrent difficulties have been encountered. Soldiers without adequate hands-on experience were not proficient on the new equipment. Optimal utilization of the information available could not be made due to the lack of solid SOPs and tactics, techniques and procedures (TTPs) for the use of digital systems. Difficulties in managing the information, to include data entry and actions required when equipment failed, were compounded by problems in determining who needed what information and when. (See Elliott, Sanders and Quinkert, 1996, and Kolhoff, 1995, for specifics.)

Kolhoff's description of Desert Hammer included numerous lessons learned. Few new tasks were identified but many were modified. Most new tasks were related to new capabilities and the requirements of digital systems, for example, using the far target designator and POSNAV. "These tasks were few in number compared to the tasks modified by digital systems, like reporting, navigating, and C2 [command and control]. These tasks are not additions; only the nature of accomplishing them has changed" (1995, p. 41). Training efforts must recognize both new and modified tasks and integrate their procedures into the training plan. Kolhoff suggested that training tasks both "non-digitally" and then "digitally" can quickly exceed available resources. Soldiers should also be taught how to maximize or leverage the technology. Kolhoff stated that more than just primary leaders need to learn the equipment. There was no ability to delegate to subordinates, and commanders became overburdened with operating digital equipment, taking away from their roles as leader. Battle-planning platforms must not be confused with battle command platforms. Leaders must lead (Edwards, 1995).

Training should show a logical progression, starting with basic warfighting skills and field craft, progressing to operation of digital equipment, then integration into unit warfighting. Training on digital systems must be so ingrained as to be second nature. In the AWE, soldiers used the new technology when ample time was available but under pressure reverted to their comfort zone, voice messages. It may be that only repeated training can provide the insights necessary to achieve maximum benefit from new systems; embedded training and digital simulation opportunities may be needed. Along with field and simulation evaluations, units may need to conduct evaluations of digital skill proficiency, similar to the TCGST (Tank Crew Gunnery Skills Test) or the BGST (Bradley Gunnery Skills Test). Edwards (1995) suggested that digital skills be incorporated into

the TCGST; Kolhoff (1995) postulated the need for a "Master Digitizer," similar to a master gunner, who knows the systems and how to train subordinates on them. (See also Brown, 1996; Dubik, 1996a; Graham, Valentine & Washington, 1997.) Vowels also described the Desert Hammer AWE, stating that both observers and participants commented that future technology based systems should make their task "no harder than it is to do now" (1995, p.15). He urged user friendly standardized equipment and software, with common protocols, report formats, easy graphics and an electronic "roger" to enhance communication.

Warrior Focus

Initiatives in the Warrior Focus AWE (Joint Readiness Training Center [JRTC] Rotation 96-2, November 1995) included own-the-night equipment and the dismounted soldier (see U.S. Army Infantry School, 1997). Naylor (1996a) interviewed Dubik, then the AWE commander. Dubik cautioned that information management procedures developed in the pre-digital age do not suffice. There was much more information available than he knew was there, or could use, even when it had been sorted out ahead of time. He echoed the need for minimum competency in computers -- and for practice in the art of simultaneous planning (Naylor, 1996a). In his presentation to the 1996 Infantry Conference, Dubik (1996a) also commented on a lack of balance. If a unit practiced digital tasks they did not practice the old non-digital tasks -- and vice-versa. There was a hybrid system of yellow sticky notes on electronic screens instead of grease pen marks on acetate charts. The system unreliability produced a lack of confidence in some of the equipment.

Senior Infantry officers, including several who had experience with digital TOCs during Warrior Focus, identified the top issues in preparing the infantry for the Force XXI battlefield. Four key issues emerged. Respondents requested a user-friendly information management system, with appropriate training and TTPs on that system. They also requested lightweight maintainable systems, with reliable communications to support the system (Graham, Valentine, and Washington, 1997).

Focused Dispatch

The Focused Dispatch AWE was an outgrowth of Operation Desert Hammer VI but, in contrast to the broad picture of Desert Hammer, was a smaller scale series of focused experiments designed to achieve specific information. Desert Hammer simultaneously examined the overall benefits of digital systems in multiple areas of doctrine, training, leadership, organization, materiel, and soldiers. The U.S. Government Accounting Office (1995) later questioned the AWE's lack of

specific goals or ways to measure them, and absence of a baseline, comparison battalion.

Focused Dispatch was observed by personnel from the Army Research Institute (ARI) at Fort Knox, and was described in detail by Elliott, Sanders and Quinkert (1996). It comprised constructive, virtual and live-virtual battalion task force level experiments. Conducted from late 1994 through September 1995, Focused Dispatch used JANUS facilities, the Mounted Warfare Test Bed and Simulation Training Center, and the Western Kentucky Training Area near Fort Knox. The exercise was iterative in that changes could be made as needed, to produce the best possible information and feedback. Focused Dispatch included a series of pilot trials and formative evaluations of training support packages (TSPs) for movement to contact, deliberate attack and defense in sector. Digital equipment included automated command, control, and communication devices, e.g., the Intervehicular Information System (IVIS), the Brigade and Battalion Command and Control (B2C2) system, the All Sources Analysis System (ASAS), and the Improved Fire Support Automated System (IFSAS). Sanders and Elliott (1996) also developed a Focused Dispatch job aid for digital troop leading procedures.

The AWE provided a series of important lessons learned (Elliott, Sanders and Quinkert, 1996). Most lessons focused on training. The lessons were not unlike those articulated elsewhere: Soldiers must be trained to proficiency in basic skills before digitization; digitization training must be allowed to progress through the crawl, walk, run stages, with provisions made for sustainment training. Conclusions also recommended the use of progressive structured training support packages, incorporating each BOS, to maximize the effectiveness of individual and staff training in virtual and constructive environments. Digitized tasks can complement and add to existing tasks; well-planned effective training management must integrate the new, modified, and unchanged tasks.

Focused Dispatch lessons also stressed a digitized mission essential task list with tasks, conditions, and standards. Training could be self-paced, tutorials, or hands on, supplementing written material that would include SOPs and TTPs. Focused Dispatch also identified some prerequisite skills needed for the digital battlefield. General computer literacy was useful, as were information management and keyboarding skills. Training should include the use of workstations, mockups, and simulations.

The lessons from Focused Dispatch indicated also that training must be provided in all phases from planning through reorganization for all personnel -- combat arms, combat support,

and combat service support. For training assessment, observer controllers need to be digitally proficient and knowledgeable, and have proficiency criteria (tasks, conditions, and standards) for digital operations.

The problems inherent in training for the digitized battlefield - who, what, where, and when - are clearly important. The overriding question is how - particularly how to gain and maintain both the digital and back-up skills required.

PROBLEM

In a 1994 article in the Army Research, Development, and Acquisition Bulletin, Major General W. C. Arnold, then in the Office of the Deputy Chief of Staff for Personnel, was one of the first to address the problem of back-up training requirements. He remarked: "For those systems where digitization is an 'add on,' soldiers will also need to maintain proficiency with the older, analogue systems and the newer, digital systems. This will require additional training, at least until systems are upgraded to a fully digital status" (1994, p. 40).

This need for maintaining conventional (prevailing) training requirements while transitioning to digital training was also addressed by TRADOC. "Because technology fails and countermeasures are always present, we must train soldiers to perform tasks both manually and digitally...The manual means of computing fire missions, placing units on overlays, etc., is cumbersome, but a needed skill when the power goes off. The battle will not stop because IVIS goes down or a tank's icon goes out" (TRADOC, 1995, p. 17).

It is apparent that the digitized battlefield, with new equipment and new tactics, techniques and procedures (TTPs), will provide many challenges. A critical step is that of identifying "back-up" training requirements. Back-up tasks are those:

> *individual and collective tasks, which although no longer required because of the increased capabilities provided by new equipment, must still be trained because their performance would be required in the event that digital equipment is degraded or unavailable.*

In other words, what tasks will be needed to ensure readiness, particularly for a mixed force of digitized and on-digitized systems. How will those tasks be identified? By whom? How will training and sustainment training be provided? The question is how the Army can, with existing resources, meet these future training requirements.

ARI DIGITIZED BATTLEFIELD STUDIES

The ARI Armored Forces Research Unit (AFRU) at Fort Knox and the ARI Infantry Forces Research Unit (IFRU) at Fort Benning have for many years addressed the impact of new systems, technologies and equipment on the battlefield, and on individual and collective training in virtual and constructive environments. Results of some prior ARI programs have provided a foundation for the study described herein, and its two follow-on efforts. A few examples of related ARI research will be highlighted here; others are listed in the separate bibliography of related ARI reports found at Appendix B at the end of this report.

Related ARI Research

Early ARI Fort Knox research showed the major impacts on training and personnel selection caused by the introduction of the M1 tank with its new training requirements (Black & Kraemer, 1981). More recent programs have focused on new tank training devices (simulation networking (SIMNET), Black & Quinkert, 1987), and new equipment (Commander's Independent Thermal Viewer, Quinkert, 1987; 1988; 1990). An extensive program of Combat Vehicle Command and Control (CVCC) research conducted in the Mounted Warfare Test Bed at Fort Knox has documented training and evaluation of new digital systems. Lickteig (1991) laid groundwork for research focusing on the soldier-machine interface for digital systems. Others extended this research program on digital information systems to battalion-level evaluation (see ARI bibliography at Appendix B).

Under the Simulation-based Training for Lower Echelon Units - Armor (SIMUTA) program at Fort Knox, structured TSPs were developed for tank platoons, companies, and battalions using SIMNET. Extensive testing of this simulation-based multiechelon armor training program provided valuable lessons learned on training. Current research on training battalion and brigade staffs is also contributing to knowledge of unit training in virtual and constructive simulations. This research has provided the foundation for training the mounted maneuver battlefield of the future.

ARI at Fort Benning also conducted early MANPRINT and human performance research on the BFV and on soldier issues at the combat training centers. Initial testing of the future-oriented Soldier Integrated Protective Ensemble, predecessor to the 21st Century Land Warrior Program, and some digitization issues therein, were documented by Salter (1993). In a cooperative study with the Institute for Defense Analyses, ARI observed performance by small teams using sophisticated technologies on a simulated 21st Century battlefield (Salter, Knerr, Lampton, Fober

& Dressel, 1997). A survey of Infantry commanders assessed requirements for future light infantry digital tactical operations centers (Graham, Valentine & Washington, 1997).

A key investigation on the digitized battlefield was ARI's research with the Mounted Maneuver Battle Lab under the Force XXI Training Program during the 1994 - 1995 AWE Focused Dispatch. This research, discussed in detail earlier in this report, was documented in a number of reports. The most comprehensive, Elliott, Sanders and Quinkert (1996), provided an overall review and lessons learned from their observations of training, and results of questionnaires and structured interviews. Lickteig's (1996) summary report provided guidelines for formative evaluations and AWEs, and insights into the problems inherent in introduction of new materials and systems.

Although these few samples of ARI research focus on Armor and Infantry, most of the lessons learned are applicable far beyond the specific weapon platforms tested. Although findings vary from system to system, it is apparent that the success in implementation of any of the equipment improvements ultimately depends upon soldier proficiency, coupled with appropriate tactics, techniques and procedures.

Request for Additional Research

ARI's research has provided insight into some potential training problems that may occur as a result of the transition to the digitized battlefield. The Office of the Deputy Chief of Staff for Personnel, Directorate for Personnel Technologies requested that ARI provide additional information on the effects of digitization. This request suggested an effort specifically targeting the digitized battlefield, and the requirements for back-up training in the event of equipment failure or non-availability.

The ARI reports on the AWEs provided valuable preliminary data about introduction of new equipment and new technologies, and the most effective means of instituting them. The principal conclusion from Elliott, Sanders, and Quinkert remains an overall caveat to these and future efforts. In a bold and pointed statement, they declared: "Of all the important lessons learned from this AWE FD [Focused Dispatch] ... the single most important lesson learned is that the Army must continue to build on previous lessons learned. The Army should not repeat the same mistakes or rediscover what has already been done several times before" (Elliott, Sanders, and Quinkert, 1996, p. 92).

With that thought well in mind, and to gather more information on issues arising from digitization, ARI is

conducting a detailed study on digitization. The present report, the first of three interrelated study reports, provides a context for the study of digitization issues and an indication of problem magnitude. This report highlights a number of difficulties that may arise on the digitized battlefield. Also, a partial review of the recent literature focuses on the interactions between sophisticated weaponry and equipment, and the soldiers who rely on them. When and if the equipment fails, what must the soldier, crewman, or commander be able to do?

Scope of Additional Work

In the statement of work for the second and third reports in this series, ARI noted that the smaller, force projection Army of the 21st century high-tempo battlefield operations will demand an environment in which all the friendly forces can share a common picture of the battlefield. (See Statement of Work, Requirements for the Digitized Battlefield," ARI, 1996.) The scope of lessons learned includes: an imbalance in digital, back-up, and combat skill training; a lack of training materials and development (e.g., SOPs and TTPs); inadequate information management; and gaps in leadership and training proficiency.

Analysis will be made of tasks that, while potentially performed by technology, will require training to ensure minimal loss of capabilities and readiness when soldiers must back up degraded systems. Assessments will help determine whether personnel skill requirements can be attained and sustained within the scope of the current Army training system. The results of the analysis will form a basis for recommendations regarding modified skill requirements, training programs, or other solution sets, as required. The M1 and M2 systems are the study's target systems for assessing the impact of digitization, but conclusions and training recommendations should benefit other digital systems.

The study's overall scope requires a) an analysis of critical issues, b) a method for identification of key back-up tasks, and c) recommendations to training programs. Issues identified early on may minimize long-term program costs and avoid potential roadblocks to implementation. A byproduct will be identification of a systematic basis for identifying and resolving significant personnel and training issues associated with digitization. Degraded modes of operation and the effects thereof on both operators and leaders will be described. Given the results of these intertwined analyses, the "back-up" and "work-around" tasks that must be trained and sustained will be identified. The need for new or revised TTPs and innovative training delivery media will be discussed. The tasks identified will include those which most impact other tasks; those which

when they cannot be performed normally, create the most changes to performance requirements; and those which, when they cannot be performed in a normal full-up mode, require significant back-up training or alternate TTPs.

The personnel skill training requirements identified may be new requirements, or may be requirements to be able to perform tasks superseded by other, digitized or technology-based, tasks. Finally, recommendations will be made and alternative operational or technical solutions considered. These will include an estimation of the impact of digital and back-up training on training programs and policies, and recommended changes to minimize the impact while ensuring readiness is sustained.

These more detailed study efforts, conducted over several months, use the recently fielded M1A2 Abrams Main Battle Tank and the forthcoming M2A2/A3 Bradley Fighting Vehicle as exemplar systems (Campbell, Ford, Shaler, & Cobb [in prep]; Ford, Campbell, & Cobb [in prep]). These study reports address current and projected task requirements for Armor and Mechanized Infantry in Military Occupational Specialty (MOS) skill demands and training approaches. They identify tasks and training approaches for both full up and degraded operations. The efforts focus attention on current (existing) and future (digital) technical and tactical task requirements demanded of personnel operating on the digitized battlefield, e.g., the armor crewman (MOS 19K) and fighting vehicle infantryman (MOS 11M).

Selection of the Abrams and the Bradley

The conventional Abrams Tank and the Bradley Fighting Vehicle have been two of the Army's most visible and highly promoted ground weapon systems of the late twentieth century. Each has, since its initial fielding, been modernized as needed to better address the needs of the mechanized battlefield and to leverage technological advances. These improvements have, over time, increased soldier survivability and enhanced performance. Until digitization, primary improvement points have been on increasing lethality and survivability of these systems through larger engine horsepower, extended ammunition range and effects, and better armor protection. Training devices designed to improve gunnery skills and performance have also been developed. Networked vehicle simulators now help train command and control skills in a complex combined arms environment. These technologically advanced training aids, devices, simulators and simulations provide efficient standardized instruction.

More recent enhancements to these two systems, however, leverage information-based systems such as second generation FLIR imaging and computer-based systems. Advances have been made in

target acquisition procedures, and commander/gunner hand-off. Today's tank commander can acquire a target, pass it off to the gunner, and then acquire a new one, using a fully integrated sighting system.

The impact from information age advances may be greater than that from industrial age increases in the caliber of a main gun, or the effective range of ammunition. The tanks and fighting vehicles of the future will be increasingly capable of activities unknown to conventional ground forces. The M1 tank, in its M1A2 configuration, and the M2 Bradley, in its M2A2/Operation Desert Storm and M2A3 versions, will be able to provide commanders and crewmen more awareness of their battlefield situation. Digital messaging capabilities will permit both vertical and horizontal integration of a fighting unit. In the Bradley M2A3, even the soldiers in the back of the vehicle will have -- for the first time -- the ability to see the ground before they get there. These changes are considerable, and not without risk.

These two systems offer an excellent opportunity for analyzing the issues raised by digitization, and more specifically the issue of back-up training requirements. The M1 has already provided lessons learned, and the Bradley provides an opportunity for applying these lessons.

SUMMARY

In summary, introduction of new equipment without a corresponding assessment of its impact represents not only a waste of capabilities, but a prescription for failure. Waiting until the equipment is fielded may be too late. It will be necessary to change the way training is planned for and conducted. More to do in less time makes efficient and effective time use critical.

School programs of instruction (POIs) and new equipment training will accommodate some of the requirements posed by digitized equipment, but may not be sufficient. In the unit a soldier must be trained and sustained on all the skills for the current systems -- for back-up -- and on all the new skills. The only way to ensure a smooth path for military career management, and, what is more important, readiness, is to make certain that old skills are not lost while new skills are being gained. Training old and new skills is not an "either/or" decision; both will be needed.

Requirements for system redundancy only increase the numbers of tasks and contingencies required. In the event of failure, new tasks will be added to existing tasks; old tasks will not be eliminated. Just as the crewmen of the 1990s are required to

learn how to traverse turrets in manual mode, crewmen of the future must know what to do when the digital systems go down or are compromised by enemy activity. They must still know how to operate the turret (probably even in manual mode) to acquire and service targets, how to read a map, and how to communicate. The question arises as to where and when the Infantry or Armor soldier can learn the conventional skills to operate the vehicle and at the same time, learn the new tasks associated with the M1A2 or the M2A3 vehicle. Where in the POI do digital and back-up skills come? Where are they taught, and by whom? What skills currently in a POI are to be left untaught because there simply are not enough hours in the day to cover everything? Where is Heinlein's master craftsman going to learn his trade? How will he sustain it?

For personnel in the active component, and to a much greater extent, for those in the guard and reserve components, the amount of time available to prepare a soldier is limited and finite. The POI in the institution, and the training calendar in a unit are constrained and defined by resources available. Although the dollar costs associated with training are often highlighted as barriers to buying new equipment, or hiring more instructors or contractor logistical support, the high driver in training resources is time. Training calendars are already filled with, for example, small unit (squad and platoon) training, live fire and field training exercises, device time (Conduct of Fire Trainer and SIMNET), and leader simulations (JANUS). The digitized battlefield will bring more tasks to an already over-crowded unit training calendar.

New skill acquisition as well as back-up skill retention may be enhanced by the increasing availability of distance learning and other distributed training opportunities, e.g., for staff officer training. The soldier may undertake considerable self-development study before he gets to a unit or to a schoolhouse. Training materials will be increasingly available on CD ROM or on-line from the Internet. Such training must be planned for, developed, routinely updated, and the training resources (including computers and software) must be made available to soldiers at every level. Virtual and constructive training environments and programs, that increase training opportunities and efficiencies through simulation, will be needed. Opportunities for embedded training must also be maximized.

The early identification of digital and back-up training issues that require resolution or further study is critical, and must prescribe training sites and methods, and include devices and simulations. Potential consequences for tactics, techniques and procedures should also be considered, as well as recommended tradeoffs, resources, and unresolved issues or areas of concern.

Digital and back-up lessons learned on this study's target systems will apply to other digital systems as they appear on the battlefield. Lessons learned must be documented, frequently revisited, and applied.

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ACRONYMS and ABBREVIATIONS

ADO	Army Digitization Office
AFRU	Armored Forces Research Unit
ARI	Army Research Institute
ASAS	All Sources Analysis System
AUSA	Association of the U.S. Army
AWE	Advanced Warfighting Experiment
B2C2	Brigade and Battalion Command and Control
BCIS	Battlefield Combat Identification System
BFV	Bradley Fighting Vehicle
BGST	Bradley Gunnery Skills Test
BOS	Battlefield Operating Systems
C2	Command and Control
C3I	Command Control Communication & Information
CCIR	Commander's Critical Information Requirements
CID	Commander's Integrated Display
CITV	Commander's Independent Thermal Viewer
CVCC	Combat Vehicle Command and Control
DID	Driver's Integrated Display
DTLOMS	Doctrine, Training, Leadership, Organization, Materiel, Soldiers
EPLRS	Enhanced Position Location Reporting System
EXFOR	Experimental Forces
FBCB2	Future Battle Command Brigade and Below
FD	Focused Dispatch
FLIR	Forward Looking Infrared Radar
GIGO	Garbage In/Garbage Out
GPS	Global Positioning System
IBAS	Improved Bradley Acquisition Sight
IFSAS	Improved Fire Support Automated System
IFRU	Infantry Forces Research Unit
IVIS	Intervehicular Information System
ITTBBST	Innovative Tools and Techniques for Brigade and Below Simulation Training
JRTC	Joint Readiness Training Center
MOS	Military Occupational Specialty
NBC	Nuclear, biological, chemical
NCO	Non Commissioned Officer
NTC	National Training Center
PERSCOM	U.S. Total Army Personnel Command
POI	Program of Instruction
POSNAV	Position Navigation
SIMNET	Simulation Networking
SIMUTA	Simulation Based Training for Lower Echelon Units - Armor
SINCGARS	Single Channel Ground and Airborne Radio System
SITREP	Situation Report
SOP	Standing Operating Procedure
TCGST	Tank Crew Gunnery Skills Test

TOC	Tactical Operating Center
TRADOC	Training and Doctrine Command
TSP	Training Support Package
TTP	Tactics, Techniques and Procedures
XO	Executive Officer

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